FORESTRY

FRDA REPORT 138

THINNING AND UTILIZATION OF LODGEPOLE PINE STANDS IN BRITISH COLUMBIA

by
Sylvi D. Holmsen, R.P.F.

FOREST RESOURCE DEVELOPMENT AGREEMENT

Canada

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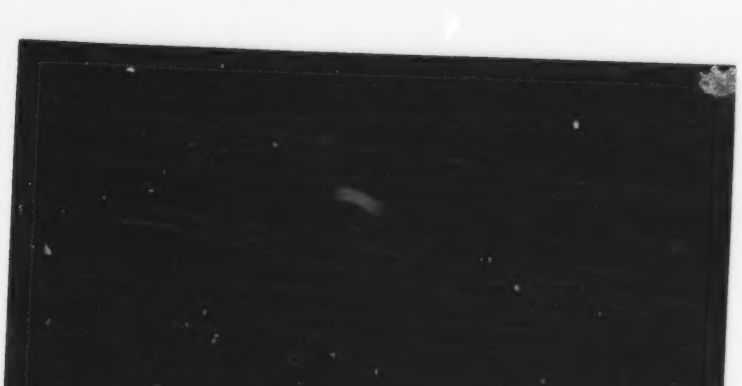

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Abstract

A study funded by the Forest Resource Development Agreement (FRDA), the Forest Engineering Research Institute of Canada (FERIC), and Forintek Canada Corp. examined the potential for thinning and utilizing 40- to 70-year-old lodgepole pine stands in British Columbia. This study included a review of literature pertaining to the thinning of lodgepole pine, an investigation of thinning activities in British Columbia, a survey of processing and marketing opportunities for this resource, and a productivity study of partial cutting in lodgepole pine. This report summarizes the results and provides recommendations for managing and utilizing this resource. The study took place in late 1989.

Author

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Preface

This study was funded by Forestry Canada under the Canada/British Columbia Forest Resource Development Agreement (1985-1990). This report has been reviewed by the Pacific Forestry Centre of Forestry Canada and approved for distribution. This approval does not necessarily signify that the contents reflect the views or policies of Forestry Canada.

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Disclaimer

This report is not intended as an endorsement or approval by FERIC of any product or service to the exclusion of others that may be suitable.

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Summary

The Forest Engineering Research Institute of Canada (FERIC) and the Pacific Forestry Centre of Forestry Canada initiated a study to examine the potential for thinning and utilizing 40- to 70-year-old lodgepole pine stands in British Columbia. The study was divided into four parts: a review of literature pertaining to the thinning of lodgepole pine, an investigation of thinning activities in British Columbia, a survey conducted by Forintek Canada Corp. of the processing and marketing opportunities for the small material created by this resource, and finally, a field study of a partial cutting operation in the Okanagan timber supply area. This project was funded under the Canada/British Columbia Forest Resource Development Agreement (FRDA). The study took place in late 1989.

Several studies conducted in Western Canada and the northwestern United States promote the silvicultural pest management and water management benefits of thinning overstocked lodgepole pine stands. FERIC's investigations in British Columbia found very few active commercial thinning operations; those that were identified consisted of minor post-and-rail sales. The economics of thinning has been unfavourable and has been a major deterrent to forest companies. Forintek identified a number of value-added products, such as furniture components and joinery stock, for which the thinnings would be suitable. The main concern of companies has been delivering this resource to the processing facility at an acceptable cost.

Because of the lack of activity in the commercial thinning of lodgepole pine, FERIC monitored a partial cutting operation to develop some productivity and cost data. A two-man crew consisting of a faller/bucker and a skidder operator with a John Deere 650G crawler tractor achieved a felling productivity of 22.6 m^3 per productive hour, and a skidding productivity of 18 m^3 per productive machine hour. Overall, productivity would be lower on a scheduled hour basis because the faller spent up to 60% of his time delimbing and bucking at the roadside or landing. FERIC estimated costs of \$4.44/m^3 for skidding, \$3.16/m^3 for falling, and \$1.99/m^3 for delimbing and bucking. The actual cost to the participating company was \$12.10/m^3. These results should be interpreted cautiously because candidate sites for commercial thinning will typically consist of trees with smaller diameters than trees examined in this study.

The basal area was reduced by 58%, and the average diameter of the residual stand increased slightly from 19.4 cm to 19.7 cm dbh. Partial cutting reduced the number of merchantable trees from 1071 trees/ha to 439 trees/ha. Damage to the residual trees was high, with 38% of the trees damaged.

FERIC recommends improving the inventory of immature forest types, developing a British Columbia Ministry of Forests contract system that would handle commercial thinning contracts, undertaking further trials which would include field demonstrations and discussions, and improving the efficiency of the harvesting phases in thinning operations.

INTRODUCTION

Several timber supply areas (TSA's) in British Columbia are faced with shortages in wood supply. Subsequent reductions in the annual allowable cut (AAC) are anticipated within the next twenty-year period, and possibly as early as ten years from now. Utilization and/or management of timber stands presently considered unmerchantable or outside the AAC determination offer opportunities to alleviate some of these projected shortfalls.

Lodgepole pine (*Pinus contorta* var. *latifolia* Engelm.) is widely distributed in western North America (Figure 1), and, although detailed inventory information is unavailable, substantial areas of older age class (40- to 70-years old) immature lodgepole pine stands exist in British Columbia. Historically, these stands have established after forest fires. Where pine densities are typically 4 000 to 10 000 trees/ha or higher, growth rate of individual stems has been reduced, although the stands are generally adding volume increment. While low rates of diameter growth and volume growth may be acceptable, in areas facing timber supply shortages treatment of these stands could increase the volume available. Research projects in Alberta (Johnstone 1982) and informal trials in the Burns Lake area of British Columbia have suggested that these stands will respond to treatment.[1] With thinning, and possibly fertilization, harvesting could be possible within 20 years.

Figure 1. Distribution of the Interior sub-species of lodgepole pine in Canada and the Pacific Northwest.

[1] Keith Van Tine, British Columbia Ministry of Forests, Lakes Forest District, pers. comm., July 1988.

The current volume within these overstocked pine stands and the sizeable area—approximately 22 000 ha in British Columbia—make thinning-to-waste inappropriate (Hedin 1988). Utilization of these thinnings is important for alleviating timber supply shortages, reducing fire hazard, and improving access for wildlife and livestock. In the past, the small material from commercial thinning operations has generated fencing and orchard products; however, these local markets are easily saturated. Efficient harvesting and processing of the thinnings, combined with improved utilization and marketing, could improve the economics and allow expansion of the thinning programs while increasing the available fibre within areas facing fibre supply shortages. This project developed from the need for a critical examination of these older immature lodgepole pine stands.

This study, funded by Forestry Canada through the Canada/British Columbia Forest Resources Development Agreement, had three major objectives:

- Investigate the market for small material, and determine volumes, cost parameters, and potential for expansion of thinning activity.
- Determine which thinning techniques are presently being used in western North America, and what products are being manufactured.
- Conduct a field trial to obtain detailed stand, productivity, and cost information on thinning or partial cutting operations in British Columbia.

FERIC reviewed the available literature on thinning and utilization of lodgepole pine, and also discussed thinning activities in older immature stands with British Columbia Ministry of Forests (BCMOF) personnel in regional and district offices to determine past and present activity in smallwood operations. Individuals involved in harvesting, processing, and marketing of this material were contacted and the current status and details of operations were established. Forintek Canada Corp. participated with a survey of the processing and marketing opportunities for the resource that would be created by such thinning operations.[2] FERIC also conducted a field study in late 1989 and early 1990 to examine the economics of partial cutting operations in small-diameter lodgepole pine stands. The results of these investigations are presented in this report.

[2] Forintek Canada Corp., January 1989, *Processing and Market Opportunities for Small-Log Lodgepole Pine Resource*, Vancouver, B.C., unpublished report. (See Appendix I.)

SCOPE OF THE STUDY

In this study, the target is 40- to 70-year-old overstocked lodgepole pine stands with 1500 to 6000 trees/ha; the trees have narrow growth rings and small knots, and are generally free of large limbs. The stands fall within the definition of Type 2 lodgepole pine stands described in two FERIC reports by Hedin (1986, 1988). These trees have small diameters (average is less than 20 cm dbh), are repressed, and have operability constraints similar to those of the poor-quality lodgepole pine found in the Cariboo Forest Region (Peterson and Giles 1988).[3] However, it is evident the tree quality is better in the immature Type 2 pine because these stands do not exhibit the defects associated with the overmature Cariboo stands; these immature stands also have higher volumes because of the higher stand density.

Target densities after treatment vary from 400 to 1000 trees/ha. Thinning treatments in these stands would involve commercial thinning corridors for skid trails with selective removal of stems within leave strips. These treatments may utilize mechanical or hand falling methods and small skidding machines. The selected stands must be accessible and relatively close to processing locations to ensure the economic viability of the operation.

Stands fitting the target descriptions are found primarily in the Prince Rupert and Kamloops Forest Regions. Three TSA's—the Lakes, Morice, and Okanagan—have been identified as having substantial areas of treatable older lodgepole pine stands, as well as having projected shortages in timber supply. In addition, other TSA's in the Kamloops, Prince George, and Nelson Forest Regions have significantly large areas of these pine stands (Hedin 1988) (Figure 2).

REVIEW OF THINNING RESEARCH

Grewal (1987) reveals that a substantial amount of information has been published throughout the world on lodgepole pine management and wood handling. As well, other literature surveys, symposia, and research projects in British Columbia and other parts of North America have examined the management and utilization of lodgepole pine stands (Reid, Collins 1983; Baumgartner et al. 1985; Barger 1987).

Benefits of Thinning

Thinning has numerous benefits: pest management, salvage of mortality, and improved quality of remaining stand. Also, concentrating volume growth on fewer larger stems reduces the time required for the stand to become operable for harvest. In addition, utilization of the thinnings rather than thinning-to-waste could reduce the fire

5 Cranbrook
7 Golden
11 Kamloops
14 Lakes
16 Mackenzie
18 Merritt
20 Morice
22 Okanagan
23 100 Mile House
24 Prince George
26 Quesnel

Figure 2. Timber supply areas identified as having major components of overstocked 40- to 70-year-old lodgepole pine.

[3] A stand is considered operable when factors such as stand and site conditions, markets, and accessibility allow the stand to be economically harvested.

hazard in the stand, and improve access for wildlife and livestock.

Sanitation thinning for pest management reduces the mortality and growth losses in lodgepole pine caused by a number of insects and diseases. Of particular interest to forest managers is the control of mountain pine beetles (*Dendroctonus ponderosae* Hopkins); infestation has reached epidemic proportions in parts of British Columbia and the northwestern United States. The benefits of thinning or partial cutting lodgepole pine as a means of managing mountain pine beetles have been extensively documented in Montana studies (McGregor et al. 1987; Amman et al. 1988) and summarized in the proceedings of several symposia (Baumgartner et al. 1985; Amman 1989). Most studies have shown that, for a number of reasons, thinned stands are less susceptible to attacks of mountain pine beetles. Thinning affects the microclimate by increasing insolation, light intensity, and wind movement, and by reducing humidity. These environmental factors have been shown to be more important than tree vigour in reducing tree losses and damage due to an infestation of mountain pine beetles (Amman et al. 1988).

Daniel, Helms, and Baker (1979) state that the main purpose of thinning is "to salvage and utilize material that would normally be lost through natural stand mortality." As well, the authors state that thinning improves the quality of the remaining stand, and distributes volume growth on fewer larger stems. By concentrating this growth, thinning shortens the economic rotation of the stand because trees in a thinned stand reach a merchantable diameter sooner than trees in an unthinned stand. This reduction in time to operability is also discussed by Dahms (1971) who found that thinning healthy 50- to 60-year-old stands could provide enough increase in diameter growth to substantially increase the number of trees over the merchantable limit by the time of harvest. The possibility of improving the merchantability of dense lodgepole pine stands and reducing the rotation age is important for alleviating future timber supply shortages.

Thinning Response

Johnstone and Cole have provided extensive reviews of the literature and studies pertaining to the thinning of lodgepole pine stands (Cole 1975, Johnstone 1985). However, despite the availability of literature on the management of lodgepole pine, in general, the two researchers note that the research database for the thinning of older lodgepole pine is limited and fragmented (Johnstone and Cole 1988).

Johnstone (1982) examined the results of a 1941 thinning trial in Alberta. A dense stand of 77-year-old lodgepole pine was thinned, removing about 70% of the total volume and reducing the stand density from 7200 to 1710 trees/ha. Permanent sample plots were established in 1949 and monitored until 1963 to determine the effects of thinning on stand development. Thinning of this stand stimulated the growth of the pine trees, increasing the diameter growth and the volume increment of the stand. Mortality was reduced substantially in the thinned stand. The results suggest that thinning older stands may be considered an option for relieving future timber supply problems.

Alexander (1960) discusses the thinning of several even-aged lodgepole pine stands in Colorado and Wyoming. These stands ranged in age from 35 to 78 years old with densities ranging from 5000 to 52 000 trees/ha before thinning. In his studies, he found that thinning effectively increased diameter growth and reduced the mortality caused by the suppression of smaller trees. Alexander also found that post-thinning diameters and stand density may be used to accurately estimate diameter growth response.

Smith and Oerlemans (1988) studied the growth response and economics of commercially strip thinning a 45-year-old jack pine stand in Ontario. Based on the 10-year growth response, the authors projected an increase in mean tree volume of between 18 and 22% by age 70, or a reduction in rotation age of eight years. The authors also found that the net present value (NPV) appeared to be most sensitive to changes in diameter and stand density as well as the discount rate. Small increases in the average diameter would result in large increases in NPV in the thinned stand and decreases in NPV in the unthinned stand.

Several studies also noted that fertilization with nitrogen following thinning of these older lodgepole pine stands improved the growth response (Bella 1978; Yang 1985). However, Bella also noted that pine stands older than 70 years may not respond well to thinning and fertilization.

FERIC's examination of the literature about thinning and fertilizing overstocked lodgepole or jack pine stands indicates that 40- to 70-year-old lodgepole pine can be expected to respond to thinning treatments, providing yield benefits that may not be realized if these stands are left unmanaged.

SUMMARY OF THINNING ACTIVITIES

Through field visits and telephone conversations, FERIC compiled a record of activities occurring in smaller-diameter lodgepole pine stands in British Columbia from 1987 to 1989. Although the primary concern of these investigations was commercial thinning, this record also included mention of clearcut harvesting operations where tree size and stand density were similar to this study's target stands.

Thinning Trials in British Columbia

In 1987, the BCMOF was involved in several informal mechanized commercial thinning trials near Burns Lake with a Makeri 34T feller processor and a Bobcat feller buncher. These trials met with mixed results; although the machines were capable of operating successfully in the lodgepole pine stands, the operations, at least with the Makeri, were not economically viable because of the high cost of extraction and the relatively low market value of the wood. Attempts to establish additional trials and operational thinning programs of this type in the Lakes Forest District during the period of the study were not successful. Recently, Vernon Forest District has been the most active, with several sales for conifer release and mountain pine beetle protection.

Under the present system, the BCMOF has used two methods for establishing thinning contracts: the timber sale licence (TSL) and the silvicultural contract. Under the Small Business Enterprise Program, approved contractors may bid on TSL's for commercial thinning; however, the stumpage appraisal system acts as a disincentive to Interior operators and licensees. The cost allowances in the appraisal system do not reflect the increased costs or the silvicultural benefits of thinning, although some districts will award TSL's at a minimum stumpage rate of $\$0.25/m^3$. The stumpage costs combined with the current low wood prices, the low volume extracted, and the high cost of extracting the wood make thinning and utilization of lodgepole pine unattractive. It is difficult, if not impossible, for a commercial thinning operation to cover costs with revenue; therefore, thinning is frequently not a profitable venture as a timber sale.

Silvicultural contracts for thinning lodgepole pine have traditionally targeted younger stands for thinning-to-waste; in older stands, this practice creates excessive debris loadings. To date no contracts have combined both the silvicultural and the timber components. Although some BCMOF district offices have accepted written proposals which may incorporate these two components, at the time of this report, no contracts had been established.

Crestbrook Forest Industries Ltd. carried out some commercial thinning trials in southeastern British Columbia from 1979 to 1984 in stands of Douglas-fir that had minor components of lodgepole pine. The ages ranged from 55 to 90 years. The crop trees, mainly Douglas-fir, were marked, and the remaining trees manually felled. Horse logging was used in one block; however, it was discontinued for several reasons (primarily low productivity and high site disturbance) and replaced by a John Deere 550 crawler tractor. This small machine minimized skid-trail width, and its power enabled it to push down leaning trees and to deck logs.

Additional Activities in Lodgepole Pine

The United States Forest Service in Montana has an active sanitation thinning program to control mountain pine beetles and to salvage mortality. Stands considered at high risk are thinned to reduce their susceptibility to attack. All infested trees are removed from the stand and only healthy trees are marked with paint or flagging and designated as crop trees. Small crawler tractors are used for skidding to keep the damage below 25% ratio of the leave trees.[4]

Since 1988, there have been few trials or major operational attempts at the commercial thinning of lodgepole pine in British Columbia. A number of small post-and-rail sales exist in several of the forest districts, but these satisfy predominantly local markets and are active only when the market is good (Figures 3 and 4). Because the economics are marginal, with a low-to-no-immediate-return on investment, companies and the BCMOF have been reluctant to try commercial thinning on an operational or trial basis. However, several companies are interested in small lodgepole pine as a raw material for their structural wood product mills. This interest has led to the BCMOF issuing several "opportunity wood" licences for the clearcut harvesting of small-diameter lodgepole pine in the Merritt, Vanderhoof, and Quesnel Forest Districts. These timber sales specify a high utilization in stands that have 50% of the volume coming from trees with diameters less than 17.5 cm dbh.

[4] Summarized from United States Forest Service silvicultural prescription provided by R.A. Willis, Weyerhaeuser Canada Limited, October 1989.

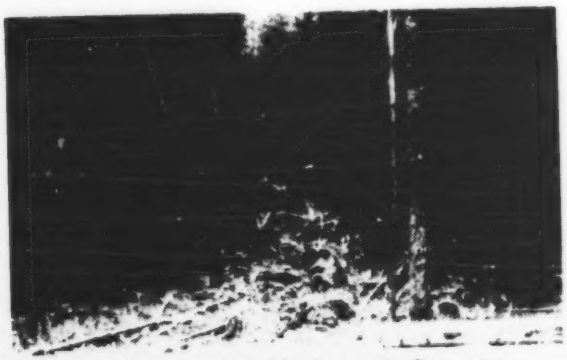

Figure 3. Commercial thinning sale for posts and rails in Kamloops TSA. Note corridor for skid trail in unthinned stand.

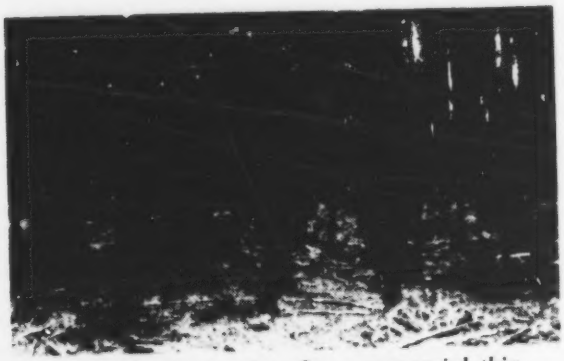

Figure 4. Kamloops site after commercial thinning for posts and rails.

Much of the harvested material is manufactured into value-added products such as panelling and joinery stock. Harvesting is done conventionally with feller-bunchers and, usually, wheeled skidders; trees may be processed mechanically or motor-manually at the landing or roadside.

Recently several companies have expressed interest in partial cutting and thinning for the purpose of controlling mountain pine beetles. At the time of writing this report (spring 1990), two companies in the southern Interior had started thinning or partial cutting operations in lodgepole pine with this objective.

POTENTIAL FOR UTILIZATION

As part of this project, Forintek Canada Corp. carried out a market study to investigate the present and potential markets for small lodgepole pine in the Lakes, Morice, and Okanagan TSA's.[5] The primary method for determining product supply and demand was through telephone surveys of the forest industry, government agencies, contractors, and others associated with the industry. This study included identifying present capabilities for the manufacturing and utilization of small wood, identifying the additional products that may be manufactured from this resource, and examining the market potential for these products. Forintek also used a computer simulation program to compare lumber recovery factors (LRF) for several possible product mixes. The results of this study are presented in detail in Appendix I.

Forintek's study found that "successful utilization of this small diameter wood appears to be linked to product diversification and taking advantage of superior wood quality. Specialized products [such as value-added]...offer recovery opportunities not available to a mill cutting only for the dimension market."[6] Computer simulation of the cutting patterns indicated that the LRF increased when lumber with narrower dimensions was included. The metric dimensions had lower recoveries, but premiums paid for these sizes may provide economic advantages. Although small in diameter, this resource has wood properties "which can be used to advantage for high quality furniture components, MSR [machine stress rated] lumber, panel products and joinery stock as well as roundwood products."[7] These properties include close growth rings, tight knots, and few branches. Forintek's study has suggested that the economics of utilizing this small-diameter lodgepole pine resource will depend on sawing technology, quality control, cutting patterns, and product price. A report by Deloitte Haskins & Sells/Carroll-Hatch International (1988) confirms that properly manufactured lodgepole pine joinery stock has the potential to replace Scandinavian joinery grades in European markets. This would provide a high-value market for pine products. Survey participants expressed more concern about the availability of timber and the cost of raw material delivery to the mill than about market demand for the wood products.

Forintek's report recommended:

- Utilization of small-diameter lodgepole pine stands (Stocking Class 4) be encouraged.
- Larger forest operators, who have no harvest

[5] See Footnote 2.
[6] See Footnote 2.
[7] See Footnote 2.

plans for Stocking Class 4 stands within their operating boundaries, be given incentives to allow small operators access to this volume.
- More innovative evaluation and allocation methods be devised to reflect that silvicultural benefits to this resource may not accrue to the current operator.
- Market development and product promotion be encouraged, established, and sustained by the provincial government to assist in the achievement of Regional silvicultural goals.

PARTIAL CUTTING TRIAL IN BRITISH COLUMBIA

FERIC examined a number of stands in the Okanagan, Kamloops, and Lakes TSA's and cooperated with licensees and the BCMOF in attempting to set up field trials of commercial thinning in lodgepole pine. However, licensees and the BCMOF have been inactive in the commercial thinning of overstocked lodgepole pine stands for the last few years, and FERIC had no success in finding a suitable site and cooperator for a study at the time of this project. Because many overstocked stands are not considered merchantable, they are not included in the AAC determination and very little inventory or growth-and-yield data are available on these stands. This lack of adequate data was also found to be a problem in the poor-quality overmature lodgepole pine stands common to the Cariboo Forest Region (Peterson and Giles 1988).

To obtain data about the effect of partial cutting on falling and skidding productivity, FERIC elected to examine an operation on one of Weyerhaeuser Canada Limited's licences in the Okanagan TSA. This study occurred over a total of four weeks, between early November 1989 and the end of January 1990, and included pretreatment assessment of the stand, detailed timing of portions of the falling and skidding phases of the project, and a post-treatment assessment of the residual stand. The results from this study will indicate the potential economic feasibility and handling techniques for the commercial thinning of overstocked lodgepole pine stands. However, caution must be used when interpreting the results because the target stands for thinning will differ from this stand in piece size and, subsequently, value and handling costs.

The increasing interest in partial cutting has developed out of a number of resource concerns in the Okanagan area. In addition to controlling mountain pine beetles in infested or susceptible stands, companies and BCMOF personnel must consider such issues as watershed protection, range management, wildlife, and aesthetics.

Description of Site

The study site was located in the Hydraulic Creek drainage approximately 40 km east of Kelowna. This drainage, and neighbouring ones, are characterized by large areas of mountain pine beetle infestation and subsequent extensive clearcuts as the forest industry attempts to control the spread of the beetle and to salvage dead or dying timber. Many drainages are also important to Okanagan Valley communities for water supply.

Generally, the geography and ecology of this area are typical of Interior lodgepole pine sites. The terrain is easy and gently rolling with occasional steeper slopes. The sites have very little debris, and minor underbrush, although there are some deadfalls and blowdown.

Pretreatment Evaluations

As part of the pretreatment evaluations, FERIC operationally cruised the study block with variable area plots using a Basal Area Factor (BAF) 5 prism. Parallel strips were established 75-m apart and the cruise plots were located at 75-m intervals along these strips. The data from this cruise was compiled and summarized by Reid, Collins & Associates Ltd. The stand was approximately 110 years old with a major component of lodgepole pine, and some dominant and co-dominant Engelmann spruce (*Picea engelmanii Perry*) and subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.) (Figure 5). The moderately developed understory consisted of spruce and subalpine fir. Selected lodgepole pine trees had been baited with pheromones to concentrate mountain pine beetle attack in a few trees that could then be removed from the stand.

Figure 5. Lodgepole pine stand near Kelowna, before partial cutting.

Beetles were evident in numerous green-attack and some red-attack lodgepole pine in pockets surrounding the baited trees.[8]

Species composition, by volume, was 94% lodgepole pine, 5% subalpine fir, and 1% Engelmann spruce; and, by basal area, was 93.3% pine, 5.6% subalpine fir, and 1.1% spruce. Table 1 summarizes the characteristics of this stand.

Description of Equipment and Crew Organization

For this partial-cutting trial, Weyerhaeuser used one of its contractors who had previous experience working with small logging contracts and salvage operations. The crew consisted of two men: a faller/bucker and a skidder operator. A Husqvarna 168 chain saw was used for the falling phase and a 1989 John Deere 650G crawler tractor equipped for skidding with a winch, a fairlead, and five chokers was used for the skidding phase. Specifications for the crawler tractor are provided in Appendix II.

Table 1. Stand Description

Cutting area	11.8 ha
Slope	
Range	1-22%
Average	13.6%
Aspect	Southeast
Terrain	Level to gently rolling
Exposed rock	Occasional
Underbrush	Light
Obstacles	Some blowdowns
No. trees/ha	
Merchantable	1 071
Understory	218
Dead, unmerchantable	248
Estimated volume	
Gross/ha	298.6 m^3
Net/ha	287.4 m^3
Gross/tree	0.28 m^3
Basal area	31.8 m^2/ha
Average dbh	19.4 cm
Average age of stand	110 yrs

[8] Green-attack trees have been infested with beetles, but are still alive. Red-attack trees have been infested, and have recently died, their needles turning a reddish colour.

At the start of the study, both the faller and the skidder operator felled a sufficient number of trees for skidding to continue without being impeded by the falling phase. The skidder operator then began skidding the whole stems and the faller divided his time between falling, and delimbing and bucking the skidded stems.

The stems were skidded whole to the roadside or an existing landing where they were delimbed, topped, and decked (Figure 6). Several times per week, a second contractor with a self-loading logging truck equipped for off-highway loads transported the wood to the mill. It was possible to haul up to two trips per day, but, given the production of the faller and skidder, the contractor averaged approximately 1.5 loads per day from the site to Weyerhaeuser's Okanagan Falls mill.

Stand Prescriptions

Weyerhaeuser's objectives for this project were to determine if partial cutting would be economically viable in selected lodgepole pine stands; if it would be possible for the faller to select the crop trees rather than have them premarked; if partial cutting is effective as a tool for managing infestations of mountain pine beetles; and if partial cutting is effective in minimizing the hydrological impact of harvesting within a watershed. Partial cutting of this stand defers clearcutting while allowing the salvage of beetle-infested lodgepole pine trees and reducing the beetle susceptibility of the remaining stand. Crop trees and spacing were selected according to the following criteria:[9]

- Cut all lodgepole pine trees greater than or equal to 17.5 cm dbh unless the prescribed

Figure 6. Skidding whole trees to the landing.

[9] M. Jobke, Weyerhaeuser Canada Limited, Okanagan Falls Division; personal communication, November 1989.

spacing will be exceeded.

- Select crop trees for larger diameters; dominant or co-dominant crown class; straight trunks with least lean, sweep, crook, or taper; large healthy crown (minimum of 25% of height); light branching; firm roots or deep rooting habit. All spruce and balsam are reserved unless they are dead, blown down, or likely to blow down.
- Remove all beetle-infested trees or previously infested trees regardless of the resulting spacing. Where openings are created in removing these trees, reduce the spacing between the remaining crop trees by 50%.

The block was divided into four areas for the trial (Appendix III). Areas 1 and 2 were prescribed a maximum spacing of 5.4 m for a leave-tree density of approximately 400 trees/ha; Areas 3 and 4 were prescribed a basal-area reduction of 50% (Table 2). In Areas 1 and 3, the leave trees were flagged by Weyerhaeuser to train the faller in tree selection for the two prescriptions. In Area 2, the faller chose the crop trees, but was instructed to keep the spacing similar to that in Area 1. In Area 4, the faller also chose the crop trees, but maintained spacing and basal area as in Area 3.

In Area 1, no skid trails were designated; these were created by the crawler operator during the skidding phase. In Area 2, the faller cleared skid trails first, but their locations had not been designated by the forester or logging supervisor (Figure 7). Prior to falling in Area 3, the forester designated the locations of the skid trails to improve the efficiency of the skidding phase, and to reduce the damage to the residual stand. In Area 4, the faller selected the location of the skid trails based on the criteria employed in Area 3.

Results of Time Studies and Productivity Assessments

FERIC collected detailed timing data for all falling and skidding phases. For the purpose of discussion, data for Areas 3 and 4 are combined (Area 3/4). Because of the short-term nature of this study, FERIC did not include delays over ten minutes in the assessments.

Falling. The distribution of productive time for the falling phase of the study is presented in Table 3. Overall, the faller spent 42.2% of the productive time actually falling trees; the remainder of his time was spent primarily in the elements of moving between trees, examining the tree prior to cutting, and brushing. Minor delays, including servicing and repairing his saw, and interruptions by visitors, comprised up to 10% of the total time the faller spent in the stand. In Areas 1 and 2, the average cycle time (the time for the faller to fall one tree and move on to the next) was slightly less than one minute, while in Area 3/4 it was

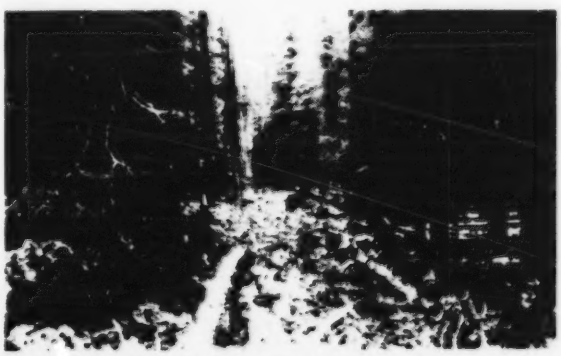

Figure 7. Cleared skid trail in Area 2.

Table 2. Prescription Summary for Study Block

	Area 1	Area 2	Area 3	Area 4
Spacing prescription	Reserve 400 trees/ha, maximum spacing 5.4 m	Reserve 400 trees/ha, maximum spacing 5.4 m	50% basal-area reduction	50% basal-area reduction
Criteria	All pine ≥17.5 cm dbh removed	All pine ≥17.5 cm dbh removed	Even size distribution removed	Even size distribution removed
Crop trees	Marked	Faller selection	Marked	Faller selection
Skid trails	Randomly located during skidding phase	Located by faller	Designated before falling	Designated before falling

Table 3. Results of Detailed Timing for Falling Phase

	Average time/cycle							
	Area 1		Area 2		Area 3/4		Weighted average for all areas	
	min	% falling cycle	min	% falling cycle	min	% falling cycle	min	% falling cycle
Falling cycle								
Move	0.21	26	0.29	31	0.41	37	0.29	31
Observe	0.09	11	0.13	14	0.09	8	0.10	11
Brush	0.05	6	0.04	4	0.29	27	0.12	13
Buck windfall	0.03	4	0.01	1	0.02	2	0.02	2
Subtotal	0.38	47	0.47	50	0.81	74	0.53	57
Cut/wedge	0.43	52	0.45	49	0.29	26	0.39	42
Delimb/buck	0.01	1	0.01	1	0.00	0	0.01	1
Total falling cycle	0.82		0.93		1.10		0.93	
Delay [a]	0.12		0.07		0.11		0.10	
Total time studied (h)	7.38		3.28		6.13		16.79	
Number of cycles	474		199		307		980	
Merchantable trees (no.)	482	100.0	171	73.4	327	69.1	980	82.5
Snags trees (no.)	0	0.0	62	26.6	146	30.9	208	17.5
Merchantable volume (gross m^3)	168.7		87.2		88.3		344.2	

[a] Includes delays less than 10 min, delays >10 min were considered nonproductive time and were not included in the results.

slightly longer than one minute. However, the differences between the three average cycle times are minor due to high variability. Although the cycle times were not very different, major differences occurred in the distribution of the time for each area. In Area 3/4 the faller spent a substantially higher proportion of his time brushing or cutting small-diameter unmerchantable trees, and a lower proportion falling, than in the other two areas.

Skidding. Table 4 presents the distribution of time in the skidding phase of the study.

Average cycle time was 14.4 min with an average skidding distance of 82 m and an average turn size of 11.2 pieces. There was considerable variability in the total turn times measured in each of the areas studied. In Area 1, the average time was 12 min, in Area 2 it was 16.4 min, and in Area 3/4 it was 18.8 min. The differences in the average turn times can be explained by several factors: longer skidding distances increased the travelling times, and the hooking and positioning times increased from Area 1 through to Area 3/4. Because of the prescription for Area 3/4, the felled trees were further apart and the skidder operator spent more time maneuvering and hooking up to get a full turn.

Productivity. To estimate gross merchantable volume extracted during the skidding phase, FERIC scaled sample turns and compiled volume figures. These volume estimates were then used to calculate gross piece sizes for each of the treatment areas and for the whole block. The average piece sizes were applied to the timing data to determine the falling and skidding productivities during the timing periods (Table 5). The average daily production for delimbing and bucking was assumed to be equal to that of the skidding phase, which was 89 m^3 based on an 8-h day at 60% utilization.

Falling averaged 22.6 m^3 per productive hour (PH). The productivity was highest in Area 2 where the piece sizes were larger, and lowest in Area 3/4

Table 4. Results of Detailed Timing for Skidding Phase

	Average time/turn							
	Area 1		Area 2		Area 3/4		Weighted average for all areas	
	min	% of skidding cycle	min	% of skidding cycle	min	% of skidding cycle	min	% of skidding cycle
Skidding cycle								
Travel empty	1.5	12	2.0	12	2.5	13	1.8	12
Position	3.5	29	2.7	17	4.7	25	3.3	23
Hook	3.3	28	4.5	27	5.5	29	4.0	28
Travel loaded	2.0	17	3.3	20	4.0	21	2.7	19
Unhook	1.0	8	1.4	9	1.0	6	1.1	8
Deck	0.7	6	2.5	15	1.1	6	1.5	10
Total skidding cycle	12.0		16.4		18.8		14.4	
Delay [a]	0.6		0.9		0.1		0.7	
Total time studied (h)	13.77		14.45		5.02		33.24	
Number of turns	66		50		16		132	
Avg skidding distance (m)	45		109		166		82	
Number of pieces/turn	10.1		12.2		12.0		11.2	
Volume (m^3/turn)	3.5		6.2		3.2		4.3	

[a] Includes delays less than 10 min, delays >10 min, were considered nonproductive time and were not included in the results.

Table 5. Estimated Falling and Skidding Productivities

	Area 1	Area 2	Area 3/4	Weighted average for all areas
Falling (m^3/PH)	25.6	33.3	14.9	22.6
Skidding (m^3/PMH)	17.8	22.8	10.3	18.0
Average piece size (m^3)	0.35	0.51	0.27	0.38
Number of pieces scaled	322	159	88	569

where the trees were smaller and fewer trees had been removed. Productivity, based on scheduled hours or shift level, will be substantially lower because falling time was reduced by delimbing and bucking at the landing or roadside. These delimbing and bucking times were not recorded in detail during this study but could account for up to 60% of the faller's time.

The average gross volume skidded was 4.3 m^3/turn, or 18 m^3/productive machine hour (PMH). Area 2 again had the highest productivity primarily because it had the larger average piece size and larger turn size. Not only was the average piece size in Area 3/4 less than in Areas 1 and 2, the skidding productivity was considerably lower. Both the felling and skidding productivities appeared to depend more on piece size and cutting prescription than whether or not the crop trees were marked.

FERIC obtained scale return data for this project from Weyerhaeuser. The total volume hauled from this site was 2645 m^3 or approximately 224 m^3/ha.[10] Utilization standards higher than those required by the license and higher than those used in the cruise calculations may have contributed

[10] J. Mervyn, Weyerhaeuser Canada Limited, Okanagan Falls Division; personal communication, April 1990.

to such a high volume recovery compared to the original total net cruise volume of 287.4 m^3/ha.

Costs. The costs projected here were derived by FERIC and are not actual costs incurred by the cooperating company. The hourly machine cost for the crawler tractor was calculated using FERIC's standard costing formula (Appendix III). New machine prices and resale values were obtained from Coast Tractor and Equipment Ltd. (Coquitlam, B.C.), and repair, maintenance, fuel, and lubricant costs were estimated. The hourly rates for the faller and his equipment and for the crawler operator were estimated at $31.76 and $25.14 respectively, excluding fringe benefits of 35% of the basic hourly rates. Travel time, crew transport, interest costs, and overhead items were not included in the costing calculations. From these rates, and the productivities determined for the falling and skidding phases, FERIC estimated the costs for each phase. For costing purposes, utilization was assumed to be 60%, and the delimbing and bucking phase was assumed to have the same average daily production as the skidding phase, with the faller's time split between his two functions. The costs for each phase, based on this study, were $3.16/$m^3$ for falling, $4.44/$m^3$ for skidding, and $1.99/$m^3$ for delimbing and bucking. The total cost of $9.59/$m^3$ for the three phases is lower than the actual cost experienced by Weyerhaeuser which found that the cost of this partial cut was $12.10/$m^3$, 24% higher than their conventional method of clearcutting with a feller-buncher and grapple skidders.[11] Marking the leave trees and skid trails is an additional expense which, in this case, cost $314/ha on the areas requiring marking.

Post-Treatment Assessment

FERIC used fixed-radius plots of 7.98 m to re-examine the cruise plots for damage to the residual stand and to estimate the remaining basal area and number of trees. Damage was initially evaluated on the basis of size, location on tree, and cause. However, it snowed, and it was difficult to see the falling damage higher on the tree. And, when the snow cover increased, the skidding damage at the base of the tree was often obscured. Damage was then classified by severity: high, medium, or low. The results of the post-treatment assessment are presented in Table 6.

On average, 38% of the remaining trees showed some damage from the harvesting operation. Most of the damage was of low-to-medium severity. The proportion of trees damaged was higher in Area 1 than in the other three areas, most likely due to skidding damage because the trails were not designated prior to falling. Felling damage, e.g. small scrapes or nicks to the tree bark, was usually of low severity, although occasionally tops of smaller trees were broken off. Skidding damage tended to be more severe with broken butts and scrapes penetrating the bark and wood of leave trees. Most of the severely damaged trees were

Table 6. Post-Treatment Assessment

	Area				Weighted average for all areas
	1	2	3	4	
Basal area (m^2/ha)	10.4	10.3	17.9	14.5	13.3
Trees/ha					
Total trees	563	817	725	867	729
Merchantable trees	400	333	475	550	439
dbh (cm)					
Merchantable trees	18.2	19.9	21.9	18.3	19.7
Damage (% total trees)					
Total	67	29	28	35	38
H	13	8	9	2	8
M	32	4	10	8	12
L	22	17	9	25	18

[11] See Footnote 10.

found in Area 1 where the skid trails had not been designated. This damage level may not be acceptable under operational conditions; however, additional care in the planning and harvesting phases could help reduce the damage levels.

The number of merchantable trees was reduced from 1071 (Table 1) to 439 trees/ha (Table 6), and basal area was reduced from 31.8 to 13.3 m^2/ha, a reduction of 58%. The average diameter (dbh) increased slightly to 19.7 cm. Figures 8 through 11 illustrate the changes in stand density at Areas 2 and 4. The volume remaining was estimated from the basal area at 120 m^3/ha or 42% of the cruised merchantable volume, although the volume removed was 224 m^3/ha, indicating a higher utilization than estimated in the cruise compilation.

Discussion of Field Study

This study has indicated that partial cutting of lodgepole pine may be practical, although it may be applicable only on specific sites. The feasibility of this type of operation will be constrained by forest management goals, as well as site selection, stand characteristics, harvesting system, and availability of skilled personnel. Alternatively, depending on the management goals and timber supply conditions, it may be more viable to clearcut and reforest these lodgepole pine sites.

During this field study, FERIC organized a one-day demonstration for interested personnel representing industry and government. The overwhelming response illustrated the high level of interest in partial cutting, and the need for further trials and organized field trips, coupled with workshops or seminars to provide forums for discussion.

This partial-cutting study has combined optimum conditions with skilled operators and excellent stand and site characteristics. The applicability of the results to commercial thinning is limited; the smaller-diameter trees present additional handling problems in the form of shorter logs and smaller piece sizes, although directional falling may be easier. This study has not addressed the biological or silvicultural implications of partial cutting; it has, however, presented a position from which techniques for handling this material may be developed.

Figure 8. Plot in Area 2 before falling.

Figure 9. Plot in Area 2 following skidding.

Figure 10. Plot in Area 4 before falling.

Figure 11. Plot in Area 4 following skidding.

SUMMARY & CONCLUSIONS

Concern over predicted timber supply shortages in several TSA's of the province led to the development of this project. Harvesting and utilization of thinnings from overstocked lodgepole pine stands in these areas could provide a timber source for alleviating the shortages, and improve the quality of the residual stand. The objectives of the study were to investigate the market for the small material created by this resource, to determine the present thinning techniques, and to conduct a field study of a thinning or partial-cutting operation.

Most of the target stands can be found in the Prince Rupert and Kamloops Forest Regions. The stands, resulting from forest fires, are 40- to 70-years old with 1500 to 6000 trees/ha. The trees are generally of good quality with narrow growth rings and small knots, and are relatively free of limbs. Because the stands are immature, the trees do not exhibit the defects associated with many of the older stands.

FERIC reviewed literature on lodgepole pine management with emphasis on thinning research. Several studies promoted the benefits of thinning lodgepole pine stands for the purpose of controlling infestations of mountain pine beetles. Additional studies indicated that lodgepole pine up to 70 years old can be expected to respond to thinning treatments, providing yield benefits that may not be realized if stands are left unmanaged.

At the time of this report, commercial thinning activities in immature overstocked lodgepole pine stands are limited. During FERIC's investigations there were few active full-time operations in British Columbia although there were post-and-rail contractors actively working in the Vernon and Kamloops Forest Districts. Because the economics of thinning operations are marginal in lodgepole pine, companies have been reluctant to participate in commercial thinning on an operational or trial basis.

Forintek Canada Corp. identified a number of products that may be manufactured from this pine resource, and examined their market potential. This review found that the wood properties associated with the immature lodgepole pine were desirable for several value-added products such as furniture components and joinery stock. Additionally, many of the companies Forintek contacted were more concerned over timber supply and cost of delivery to the mill than about the market demand for their products.

The final phase of this project involved a field study of a partial cutting operation in a 110-year-old stand in the Okanagan TSA. This study was selected as an alternative to commercial thinning because FERIC was unable to find a suitable site and a cooperator for a thinning study; an obstacle to site selection and thinning prescription was the lack of adequate inventory and growth-and-yield data on immature lodgepole pine stands. The study site was located near Kelowna and had uniform terrain with little debris or underbrush. Treatments included preharvest marking of leave trees and faller selection, plus prelocation of skid trails and selection of skid trails by the skidder operator. Felling productivity ranged from 14.9 to 33.3 m^3/PH, and skidding productivity ranged from 10.3 to 22.8 m^3/PMH using a John Deere 650G crawler tractor. Both the felling and skidding productivities appeared to depend more on piece size and prescription than on whether or not the crop trees were marked. Costs, using FERIC procedures, were estimated at \$4.44/m^3 for the skidding based on 60% utilization, \$3.16/m^3 for the falling, and \$1.99/m^3 for delimbing and bucking. Weyerhaeuser experienced harvesting costs of \$12.10/m^3, up to 24% more than their normal cost of conventionally clearcutting similar sites. Tree marking cost \$314/ha in Areas 1 and 3 where the crop trees were identified prior to falling.

The number of merchantable trees was reduced from 1071 to 439 trees/ha by the partial cutting. The basal area was reduced by 58%, and the average diameter of the stand increased slightly from 19.4 cm to 19.7 cm dbh. Damage to the residual trees was high, with 38% of the trees damaged to some degree.

Recommendations

In light of the predicted timber shortages in various TSA's of the province, a number of deficiencies and concerns must be addressed. The following considerations would assist in promoting the utilization of the available lodgepole pine thinnings as a source of wood.

- To facilitate timber and silviculture planning, an improved inventory of immature forest types is required.
- The BCMOF should be more flexible when dealing with thinning of lodgepole pine stands. If the appraisal system is to be used for commercial thinning contracts in lodgepole pine stands, incentives must be developed within that framework to encourage thinning and utilization of overstocked pine types.

Alternatively, commercial thinning could be handled through special silvicultural contracts that would use the value of the wood to offset the thinning costs. This method would be particularly useful where thinning has no immediate economic advantage but would be silviculturally beneficial to the stand.

- Similar trials with field visits and discussion forums are necessary to disseminate information to field personnel and to encourage innovative thinking.
- Studies must be undertaken to examine the harvesting phases in these thinnings to determine which type of equipment would be most appropriate for handling the smaller wood generated.

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APPENDIX I

Processing and Market Opportunities for Small-Log Lodgepole Pine Resource
(Forintek Report)

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Processing and Market Opportunities

for

Small-log Lodgepole Pine Resource

prepared for

Forest Engineering Research Institute of Canada
(FERIC)

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INTRODUCTION

Areas of immature Lodgepole Pine (Pinus contorta var latifolia Engelm.), which have high stocking as a result of wildfire origin, are common throughout the interior Forest Regions of British Columbia. Stocking in these stands typically range from 4000 to 10,000 or more stems per hectare (ha). Provincial inventory statistics classify these stands as Stocking Classes 3 and 4. Growth rates on individual stands are slow, and much mortality can be expected before these stands reach merchantable stem sizes under present utilization standards.

In Timber Supply Areas where forest resource shortages are anticipated within twenty years, utilization of this resource segment through thinning or harvesting operations, offers an opportunity to alleviate the expected timber shortfall and improve future volume availability from the forest land base. Growth rates and merchantable tree size could be improved by reducing stand stocking levels through thinning or controlling initial stocking level by replacing current overstocked stands with new plantations following clear felling. Economical utilization of this resource, either by thinning or clear felling, could help offset the silviculture costs but is dependent on delivery of the resource to mills at competitive costs, efficient conversion to quality, desirable products, and market demand for the end product.

Forintek Canada Corp. has completed a preliminary investigation of the conversion and marketing opportunities for this small log resource. The findings of this study are presented in this report.

OBJECTIVE

To identify present and future manufacturing, product and market opportunities which will encourage utilization of small logs from overstocked immature Lodgepole Pine stands.

PROCEDURES

Ministry of Forests Regional resource personnel, and industry representatives from large and small primary and secondary manufacturing sectors were contacted by telephone. Utilization standards, product mixes and markets, conversion techniques, availability of the resource in each region, and operation concerns were ascertained.

The Best Opening Face (BOF) computer simulation program was used to determine relative expected lumber recovery factors, by diameter class, for small log conversion for various product mixes. Six simulation runs were completed. Saw kerf and sawing variation were kept constant for all runs, green target sizes were set to reflect above average level of technology and quality control in the industry today. Wane allowances are

built into the model, corresponding to dimension product rules. To account for less wane on some export grades, the target sizes for these lumber sizes were increased. Recovery data for log diameters from 7.6 cm to 11.2 cm (3.0 to 4.2 inches) top diameter and lengths from 2.4 to 4.9 m (8 to 16 feet) were determined for live and cant sawing methods. Recovery results, weighted by log volume, for eight diameter classes and all lengths were determined.

SURVEY OBSERVATIONS AND RESULTS

Eleven sawmills using or anticipating the conversion of this resource were contacted, but many mills are processing small wood (to 10 cm top diameter) as normal utilization standards on their regular timber quota. Production equipment, designed to handle high piece counts, process these small piece sizes into lumber for the regular product mix, which for many interior sawmills is dimension lumber. Stud production (8-foot lengths) offers an opportunity for higher recovery because small-diameter logs produce lumber which 'wanes' very quickly. Other companies have utilized the small size and special qualities of this resource to manufacture higher valued products such as panelling, joinery stock and furniture components. In general, low delivered log cost and high production volume are the two most critical variables affecting profitability from small logs, however, maintenance of sawing equipment to ensure proper alignment is also important for improved lumber recovery.

Wood characteristics:

Several wood characteristics, such as narrow rings, small and tight knots, narrow sapwood reducing insect attack, straight stems, and low occurrence of butt rot, were identified by industry personnel as being favorable for high valued products and contributory to the increased demand for this resource. Most of these characteristics can be related to the stands' high stocking densities which have produced slow-grown, fine-grained wood with tight, small knots. Some stands have been self-pruned at an early age resulting in recovery of lumber with one clear face. These characteristics make the resource suitable for joinery stock, machine stress rated (MSR) lumber and panelling.

Higher than normal stem taper, due to the young age of stands, was noted as a distinct disadvantage for lumber recovery compared with normal logs because wane restrictions would be encountered sooner resulting in shorter lumber lengths.

Debarking:

Specific debarking problems were not identified for this resource, although in general, debarking small logs can present additional operating problems if stems are crooked or deformed by external defects such as cat faces or mechanical damage. Stem straightness and lack of external defects

were cited as advantages over small stems from mature stands. Debarking during winter also requires increased knife pressure which may increase 'pencil sharpening' of log ends. One mill anticipated a problem because the barker arms would not close enough to handle small diameter logs. The use of flail debarkers was being considered by one company planning capital investment for small log utilization.

Higher bark content in chips from this resource was not identified as a concern probably because the total volume consumed, and chip volume produced, accounted for only a small proportion of the total chip production at most sawmill operations. Any operation processing small logs as a high proportion of the total log mix may experience difficulty in selling chips during an oversupply market.

Log Conversion:

No specific conversion difficulties were identified for this small log resource. Limiting factors are production rate and product dimensions. Larger sawmills are processing the wood through existing small log equipment, while some small operators have developed markets for higher valued products to offset high processing costs. Most mills were utilizing stems down to a top diameter of 10 cm (4-inch), but two mills processed down to 9 cm and one mill as low as 8.3 cm top. Metric sizes, production of one-inch or 2x3 dimension lumber offer improved recovery opportunities and these strategies have been adopted by many of the mills consuming this small wood.

Five mills contacted were using Chip-N-Saw (CNS) equipment for small log processing. A European-designed small log processor, configured similarly to CNS's, will be installed at one mill to process logs down to 8.9 cm top diameter. Another mill will be installing a Japanese designed scragg mill to process logs down to a 7.5 cm (3-inch) top diameter.

Product Mix:

Successful utilization of this small diameter wood appears to be linked to product diversification and taking advantage of superior wood quality. Specialized products, whose dimensions are smaller than the 1.75 green target thickness for dimension, offer recovery opportunities not available to a mill cutting only for the dimension market. Market niches, including local secondary manufacturers, for joinery stock, metric-sized lumber and one-inch stock, have been developed by some primary operators.
Products and markets included export lumber in 19, 26 and 50 mm sizes, joinery stock, pine panelling cut from 2x3 to 4x4 stock, dimension and stud lumber in 2x3 and 2x4 sizes, and one-inch boards. Steady market demand for most of these products have maintained prices at levels suitable to support the conversion industry.

Other products being produced or considered included treated posts for export, for which a large market demand exists, and oriented strand board

(OSB). A major interior forest company has recently announced plans to build an OSB plant with annual wood consumption of 500,000 m3 of which one third will be obtained by utilizing resource classified in Stocking Class 4.

An intensive study (Koch et al, unpublished) of the technical and economic feasibility of utilization of small-diameter lodgepole pine resource has been completed in Montana. OSB, fabricated joists and edge-glued lumber panels were identified to supply 90 percent of the revenue in a multi-product integrated conversion facility. Posts, rails, studs, chips and particle board furnish were identified as additional minor products. Fabricated joists will be made from flanges of pine dowels, 67 mm in diameter, and webs of 10 mm waferboard and are designed to compete with joists fabricated from solid wood or laminated veneer lumber (LVL) flanges and plywood webs.

Market Availability:

Small primary and secondary manufacturers expressed optimism regarding market demand for products derived from this resource. One operation indicated that current annual lumber production of 15 million board feet (MM fbm) could be doubled, but the lack of timber supply was prohibiting plant expansion. Security of a market in the secondary manufacturing sector has encouraged another operation to invest in primary equipment to process small tight-knot pine.

Market demand for composite products and conversion economics have convinced a sawmilling company to propose an OSB plant involving planned annual consumption of 170,000 m3 of Stocking Class 4 resource plus increased utilization from existing AAC. Despite the surge in OSB production in recent years and an announcement of a plant closure in Eastern Canada, this company has determined a competitive edge exists in their proposal.

One post operator would triple his present operation based on the available post market in California, but security of wood supply was hindering the expansion.

Limited timber availability and high delivery costs of the resource to conversion plants were noted by many as more serious constraints to successful operations than lack of market demand for final product.

SIMULATION

The six simulation runs were differentiated by the following product mixes:

Simulation Run	Products
1	2x3, 2x4
2	1x3, 2x3, 2x4
3	2x3
4	1x3, 1x4, 2x4
5	19x76mm, 25x76mm
6	1x3, 1x4

Recovery results, calculated as actual solid wood recovery (based on rough green target sizes) as a percentage of initial log volume, are presented below. Live sawing (all sawlines are parallel to the initial opening face) resulted in higher recovery than cant sawing (sawlines are perpendicular to initial opening face and side board cuts) because of the small log diameters.

Best Opening Face Simulation

Lumber Recovery for Various Cutting Patterns for Small Logs

Log Dimensions		Lumber Recovery (Percent of Total Log Volume)					
Diam (cm)	Length (m)	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6
7.6	2.4-4.9	40.7	39.3	43.1	42.3	-	40.9
8.1	2.4-4.9	36.9	42.1	39.3	44.9	37.4	46.5
8.6	2.4-4.9	33.5	44.5	35.7	48.4	37.3	42.0
9.1	2.4-4.9	33.9	44.3	36.1	48.2	43.5	45.2
9.7	2.4-4.9	37.5	45.8	39.1	49.3	44.1	50.9
10.2	2.4-4.9	39.7	50.6	40.6	53.9	44.1	50.6
10.7	2.4-4.9	44.0	50.7	46.8	52.6	46.6	50.1
11.2	2.4-4.9	46.4	49.1	47.2	53.8	45.9	50.6
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Average Recovery %		39.6	46.5	41.5	49.9	43.2	47.7

Lumber recovery was significantly increased for this small diameter resource when narrow width lumber was included in the cutting patterns. Although metric lumber was the lowest in thickness target size (19 mm at .87 inches versus .97 for one-inch), metric lumber recovery (Run 5) was lower than recovery for one inch because the lumber width (76mm) was above that for three-inch boards. Relative low recovery (Run 1) and low product price for dimension lumber indicate that profitable conversion of this small-log resource to the dimension market is doubtful.

Profitable recovery from this resource requires thin kerf sawing technology, high standards of quality control, well defined cutting patterns and close attention to product price. Even though metric lumber sizes indicated only five percent increased recovery over dimension products, higher product prices could improve the economic advantage for this cutting pattern.

DISCUSSION

Resource Availability:

Economic utilization of immature, small-log lodgepole pine resource will be highly dependent on delivered wood costs, conversion advantages, and final market price. Although there may be substantial volumes of Stocking Class 4 in Forest Regions now, economic harvesting and conversion of this resource will be greatly influenced by the distance from the converting facility. Much of the resource may be suitable for small business entrepreneurs, but if one large manufacturing plant is located in any Forest Region, small operators may very quickly find resource availability or cost outside their economic operating range.

A Woodbridge, Reed and Associates study (Ministry of Forests, 1984) also cited insecurity of raw material supply as a principal constraint for success of the small-size (remanufacturing) industry, indicating that this, as well as financial and marketing constraints, were the three greatest barriers to long term success.

The available volume of this resource should be considered finite since silviculture practices should reduce the area of high density stands in the future. The economic viability of any operation should be calculated on the current volume and location of stands in Stocking Classes 3 and 4 within the area of operation, and not include any future volume from unmanaged, high stocking stands.

The extent to which silviculture costs should be recovered through stumpage and other revenue from utilization of this resource must be carefully considered. If the stands are left to natural development, the crop at maturity will be older and smaller than final crop trees under a managed regime. Operators are concerned that they must pay now for future benefits that may be awarded to someone else at final harvest.

The reliability of volume estimates was a concern of an operator who stated that accurate economic calculations could not be expected when the variance in volume estimates were as high as 30 percent. Accurate net volume information is essential for determining timber bid estimates, because the profit margin for utilization of any small-log resource is reduced by higher logging, transportation and processing costs as well as lower volume and grade recovery.

Conversion:

There is industry confidence that existing technology is adequate to convert this small-log resource economically now. Product and operating strategies that consider thin kerf sawing, small-dimensioned products, and careful machine maintenance to reduce sawing variation can make the conversion of this resource economic.

Careful examination of cutting pattern, product dimension and product price will improve the revenue side of the profit equation. Expected low lumber recoveries, compared to larger diameter logs, the possibility of low chip revenue (or even rejection) because of higher bark content must be offset by the highest possible product prices.

Major lumber producers rely on high production mills and fast drying schedules to manufacture dimension products from the mature pine resource of the interior. In contrast, small business operators utilize different manufacturing and drying technology to produce high-valued products for the specific market niches which they have established. Smaller production runs of products with specific sizes and grade qualities, drying to varying final moisture contents, and other individual customer specifications are examples of the specialization capabilities of the small operator. As long as these conversion differences remain, and the small entrepreneur is able to hold his market niche, conversion of immature small lodgepole pine should continue to be economical.

Product and Markets:

These overstocked, young stands have been established and are growing under conditions which have produced a resource with excellent wood characteristics which can be used to advantage for high quality furniture components, MSR lumber, panel products and joinery stock as well as roundwood products. Establishing specific markets and maintaining those markets through production of high quality, dependable products are key to economic viability for the small operators who are presently utilizing this resource.

British Columbia Interior production of lodgepole pine lumber was about 3 billion fbm in 1986, of which less than one percent was marketed as higher value products such as joinery stock (Deloitte Haskins & Sells/Carroll-Hatch (International) Ltd, 1988). The total joinery market, based on 15 percent of wood consumption in Europe, Japan and North America, is estimated at 13.6 billion fbm which equals the total

production of softwood lumber in British Columbia for 1986. It has been estimated that 2.5 billion board feet (fbm) of joinery stock from Scandinavia marketed in Europe in the past has dropped to about 1 billion fbm today. Lodgepole pine, which has been properly manufactured and graded has been demonstrated as a suitable replacement for 'redwood' (pine) joinery grades from Scandinavia. These facts indicate an exciting opportunity for the industry to obtain premium prices for this species.

The remanufacturing industry in British Columbia consumes about 500 million fbm annually, of which 30 percent is derived from interior species. Market destinations for their product are heavy to North America (Canada 35%, USA 48%) with only 17% of the production going offshore (Ministry of Forests, 1984). The Woodbridge-Reed report also identifies a significant potential for pine furniture manufacturing in North America. One major manufacturer has been established in Canada but further market expansion is possible in the USA. There is also a promising trend towards pine panelling products as consumers appear to be moving away from imitation panel products.

There are uncertainties counterbalancing the marketing opportunities suggested above which could directly influence the successful utilization of small overstocked pine. Most of the high-valued joinery, furniture component and panelling products can also be manufactured from resource which is currently being cut into construction lumber. A small swing away from dimension production by a few of the major producers could very quickly saturate the current market supplied by secondary, remanufacturing and small business operations, unless the potential market suggested above is fully developed. This market flooding may be inevitable as profit margins decrease with current low prices for dimension reflecting the forecasted drop in housing starts in both Canada and USA during 1989 and 1990 (Forsim Review 1988).

CONCLUSIONS AND RECOMMENDATIONS

Most firms interviewed indicated that they had, or would be interested in pursuing the utilization of volumes of overstocked, immature lodgepole pine located in their operating area. Economic viability of existing operations is supported by the fact that seven operations have either made commitments to capital expansion or indicated willingness to expand except for the inability to secure a supply of sufficient volumes of the resource. There is also uncertainty about long term viability of the present industry utilizing this resource because of a possible diversification of present dimension volume into value-added production.

A wide range of products are being extracted from the resource including traditional dimension lumber, smaller dimension widths and one-inch stock, joinery, window and furniture stock, metric size lumber for export, and roundwood in the form of posts and poles. A major interior company has submitted plans to establish an OSB plant which will use presently unmerchantable pine for up to a third of its annual wood consumption.

Announced plans for a interior chipping plant may also be relying on this resource type for some of its volume.

A study in Northwest Montana has shown that an integrated complex to produce OSB, fabricated joists and edge-glued lumber products is viable over the twenty year life span, and will only use half the available resource in that region.

Recommendations concerning utilization of this resource are:

- Utilization of small lodgepole pine stands (Stocking Class 4) be encouraged.

- Larger forest operators, who have no harvest plans for Stocking Class 4 stands within their operating boundaries, be given incentives to allow small operators access to this volume.

- More innovative evaluation and allocation methods be devised to reflect that silvicultural benefits to this resource may not accrue to the current operator.

- Market development and product promotion be encouraged, established and sustained by the provincial government to assist in the achievement of Regional silviculture goals.

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APPENDIX II

Specifications for John Deere 650G Crawler Tractor[1]

Engine: John Deere 4-276T

Type	4-stroke cycle, turbocharged diesel
Displacement	4.524 L
Maximum net torque @ 1300 rpm	397 Nm
Net rated power @ 2100 rpm	67.5 kW

Transmission: Powershift (4 speeds forward & reverse)

Travel speeds

Gear	Forward (km/h)	Reverse (km/h)
1	1.9	2.3
2	3.4	3.7
3	5.3	5.8
4	8.9	9.8

Hydraulic system: Open centre

Purchase price (1990) C$94 000

Undercarriage: 6-roller track frame with Dura-Trax deep-heat-treated components

Standard track

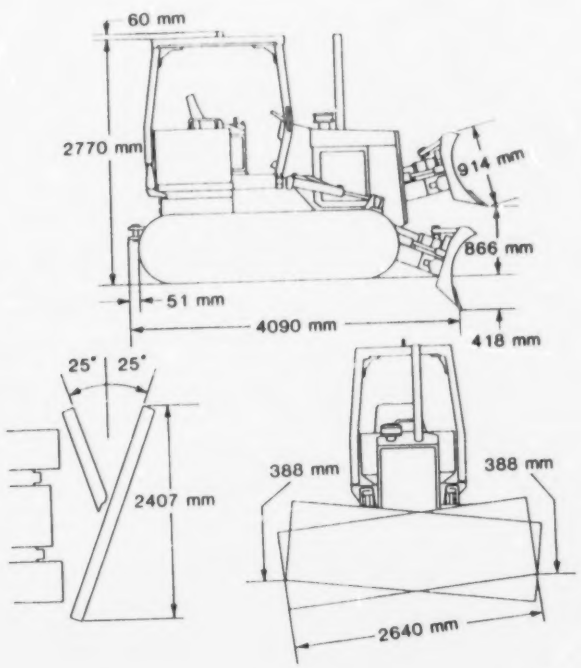
Grouser, closed centre	457 mm
Ground pressure	41.4 kPa

Fuel tank 155.2 L

SAE operating weight w/ROPS

Standard track	8 390 kg

Additional standard equipment
- Adjustable cushion seat and armrests
- Chain guides
- Decelerator
- Electric hourmeter
- Enclosed alternator with solid-state regulator
- Engine side shields, perforated
- Front and rear bottom guards
- ROPS canopy, isolation mounted, and seat belt
- Trash-resistant radiator
- Vandal protection
- Winch drive



[1] From manufacturer's brochure (1990).

APPENDIX III

Maps of Study Block

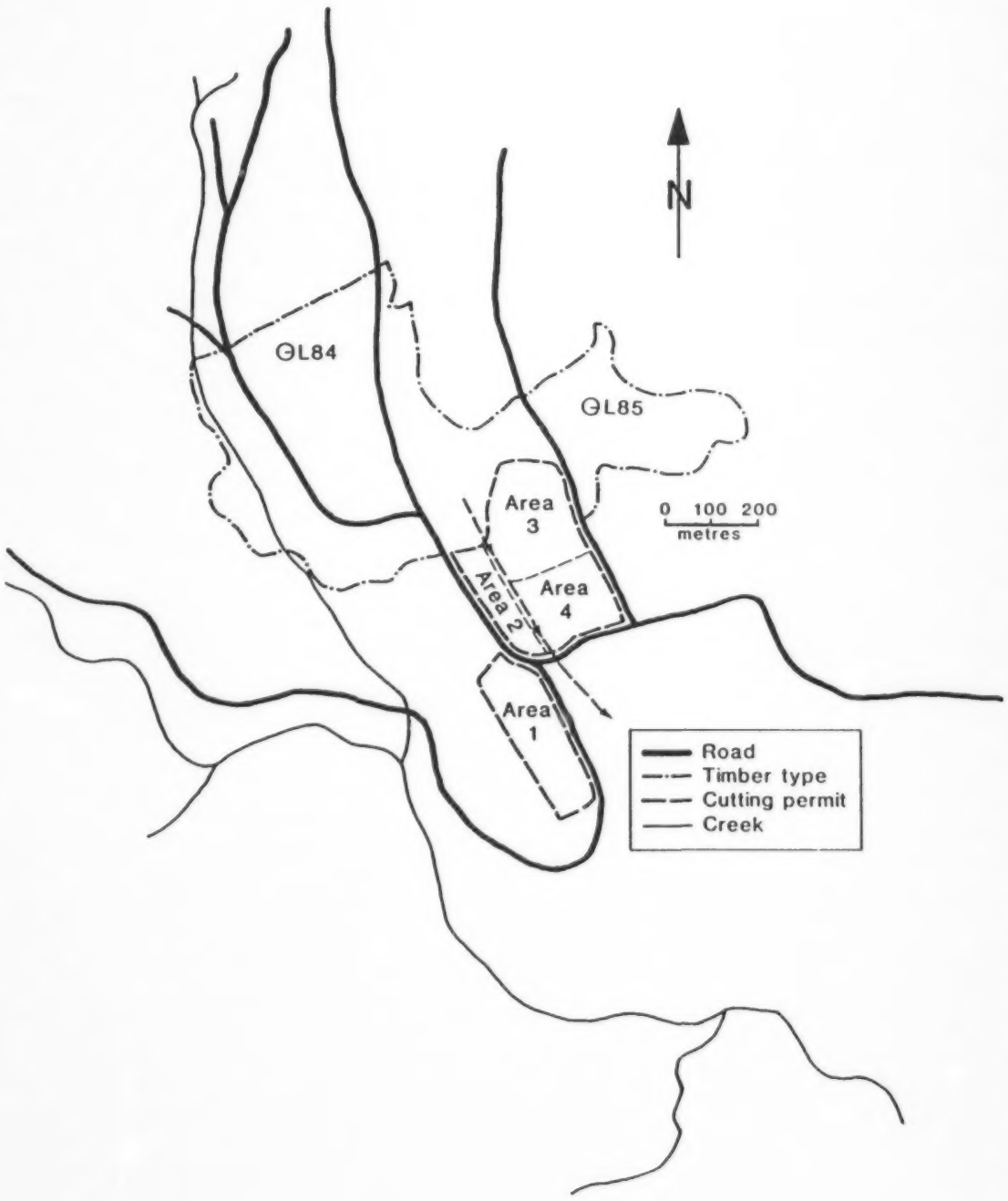


Figure II-1. Division of block into four study areas.

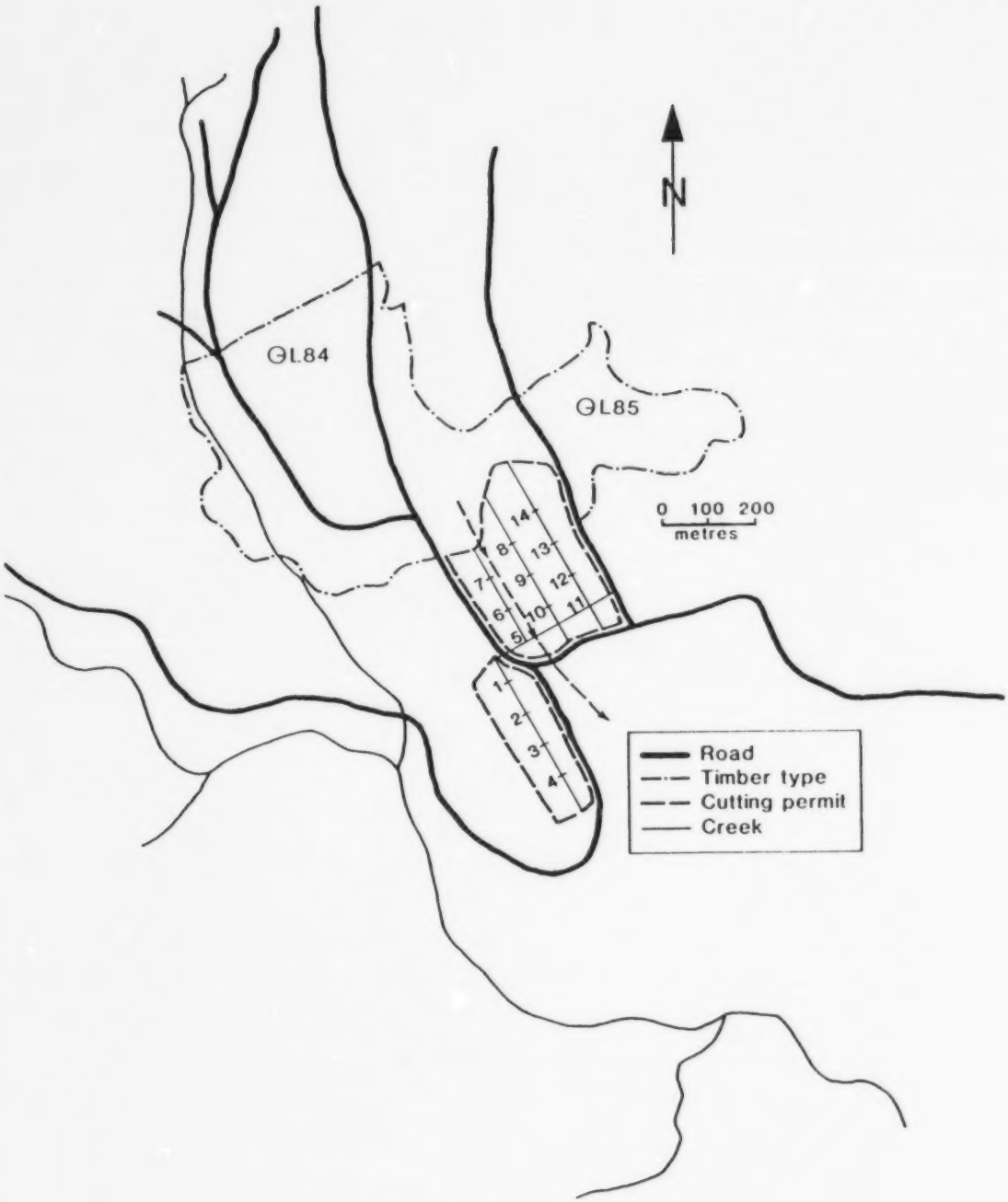


Figure II-2. Location of cruise plots.

APPENDIX IV

Cost Analysis: John Deere 650G Crawler Tractor

Ownership costs: Input	
Purchase price (P)	$94 000
Salvage value (S), (20% of P)	$18 800
Expected life (yr)	6
Expected life (h)	12 000
Interest rate (Int), (%)	15.5
Insurance rate (Ins), (%)	2.5
Ownership costs: Results	
Average investment (AVI) = [(P + S)/2]	$56 400
Loss in resale value = [(P - S)/h]	$6.27
Interest = (Int • AVI)/(h/yr)	$4.37
Insurance = (Ins • AVI)/(h/yr)	$0.71
Operating and repair costs: Input	
Hourly fuel consumption (L)	10
Fuel cost ($/L)	$0.40
Annual operating supply cost (O)	$3 000
Track and undercarriage life (TL), (h)	5 000
Track and undercarriage replacement cost (T)	$12 000
Annual repair and maintenance cost (R)	$15 000
Wages (W), ($/h)	$18.62
Wage benefit loading (WBL), (%)	35
Operating and repair costs: Results	
Hourly fuel cost = (L) • ($/L)	$4.00
Lube and oil cost = 10% of hourly fuel cost	$0.40
Operating supply cost = [(O/(h/yr)]	$1.50
Track and undercarriage cost = (T/TL)	$2.40
Repair and maintenance cost = [R/(h/yr)]	$7.50
Labour cost = (W) • [1 + (WBL/100)]	$25.14
Total operating and repair costs	$40.94
Total costs: Results	
Loss in resale value	$6.27
Insurance	$0.71
Operating and repair costs	$40.94
Total machine cost (excluding interest costs)	$47.92
Interest cost	$4.37
Total machine cost (including interest costs)	$52.29

Cost Analysis: Falling/Bucking

Falling/bucking costs: Input	
Saw, gas, and oil cost ($/day)	$0.00
Wages (FW), ($/h)	$31.76
Wage benefit loading (FWBL), (%)	35
Average shift length (ASL), (h)	8
Falling/bucking costs: Results	
Saw, gas, and oil cost = [($/day)/ASL]	$0.00
Labour cost = (FW) • [1 + (FWBL/100)]	$42.88
System operating costs: Results	
Total falling cost	$42.88
Total machine cost (excluding interest cost)	$47.91
System operating cost (excluding interest cost)	$90.78
Interest cost	$4.37
System operating cost (including interest cost)	$95.16